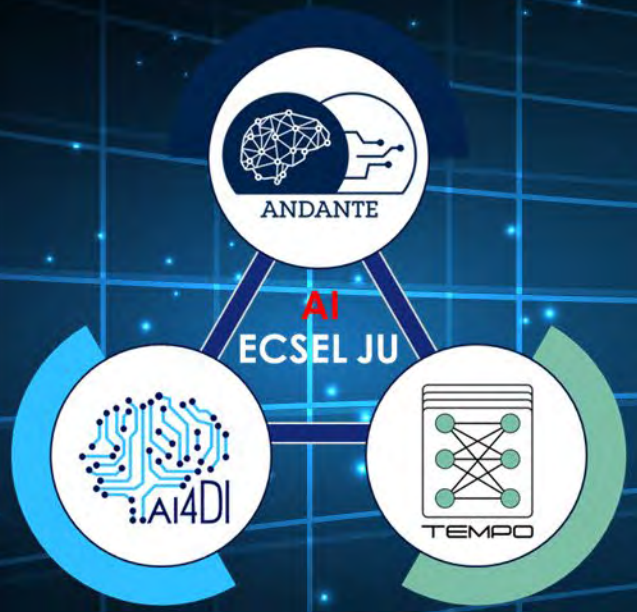
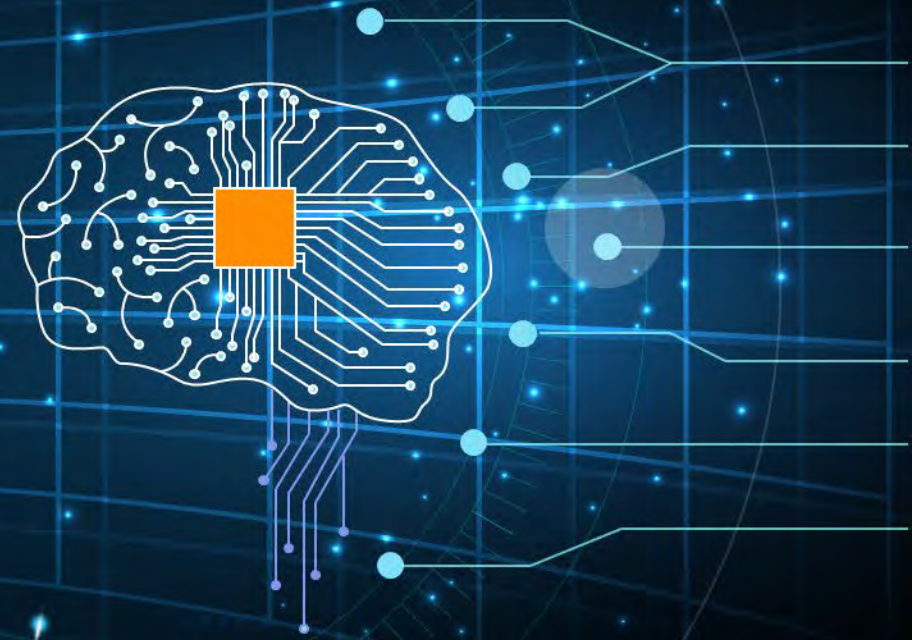
The International Workshop on Edge Artificial Intelligence for Industrial Applications (EAI4IA)





Vienna, Austria

25-26 July 2022

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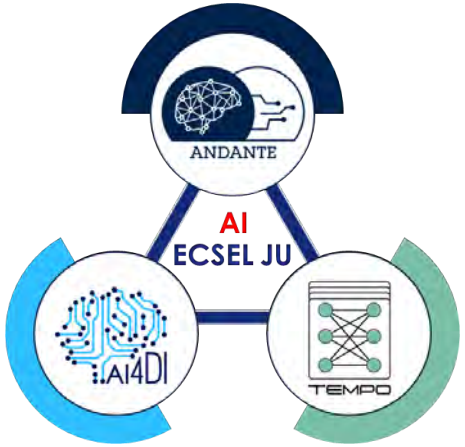


Failure detection in semiconductor package

Saad Al-Baddai, Infineon Technology AG, Germany

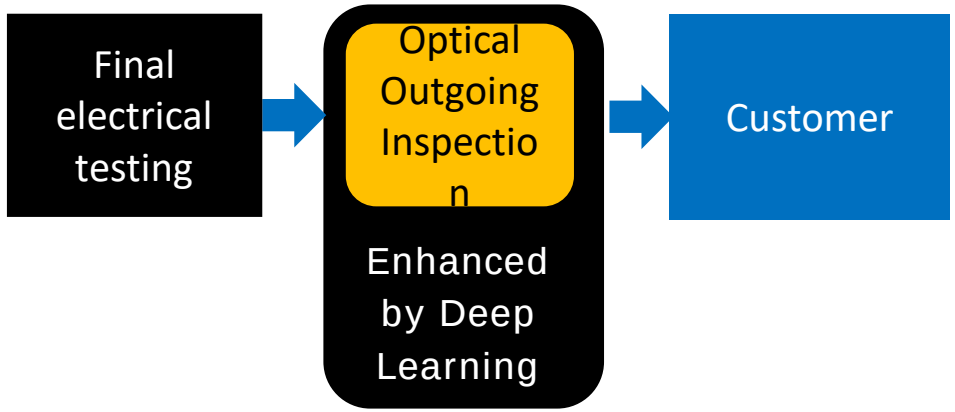
Vienna, Austria 25-26 July 2022

Presentation Outline

- Introduction & Motivation
- Research Goal
- Design and Implementation
- Experimental Results & Conclusions

Introduction & Motivation

- Semiconductor manufacturing produces the most highly advanced microchips in the world.
- In principle semiconductor manufacturing is equipped with lots of sensors to monitor the processes but it lacks a suitable way to make use of this data.
- In backend production line, the quality is the most important factor through assembly and packaging processes. In order to achieve an expected quality, the output of each process must be inspected either manually or rule-based techniques. The latter would lead to high over-reject rates which require a lot of additional manual effort. In this project two use cases are considered for showing the potential of replacing the manual/classical solution by the AI solution. These two use cases are:
  - Optical outgoing inspection (OOI) is currently executed by operators due to strong fluctuations in the optical appearance. This is due to different oxidations of the copper surface. Therefore classical computer vision is not capable for a reliable classification.
  - Anomaly detection in process control of the wirebonding process



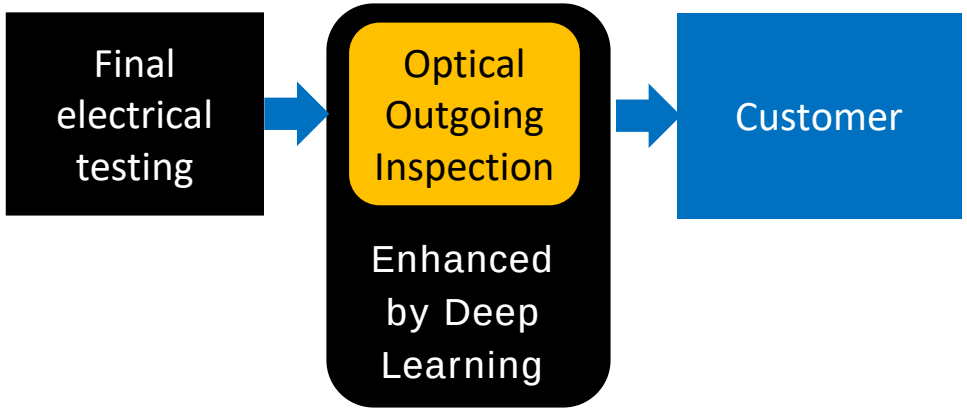
Research goal

Targets:

- Demonstrate the potential benefits of AI solution in semiconductor sector.
- Substitute the manual inspection/classical rule-based by an automatic AI solution
- Decrease workload
- Increase yield and improve the quality

Basic requirements are:

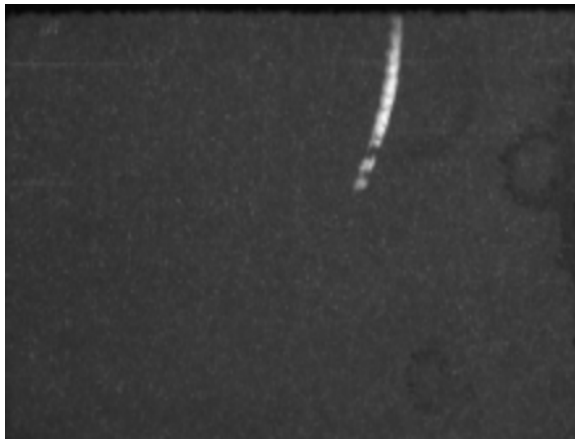
- Accuracy >= human (must)
- High speed (< 1 sec.)
- False alarm < 1 %
- Model shall be **included in productive tester environment**



Design and Implementation – collecting data and labeling

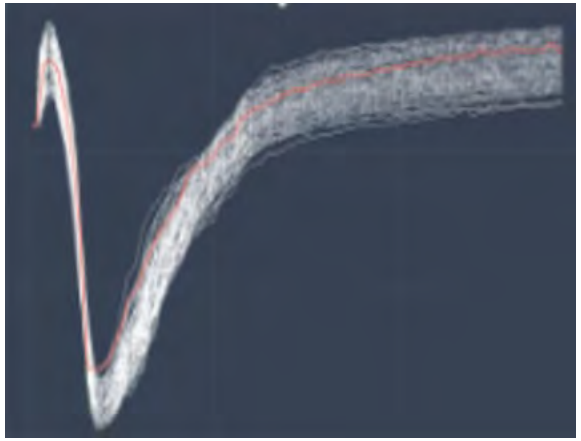
- **X→Y**

- In this approach, collected and labelling data(images) is done directly based on human experience.
- However, the challenge is that a huge data have to be reviewed to collect defect images.



- **Y→X**

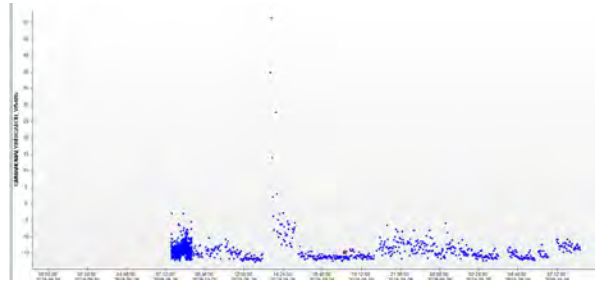
- Contrary to the first approach, in this approach human's experience unfortunately is not fully helpful for labelling data, as the data is very complex. Hence, the design of experiment(DOE) is set by checking the machine status while collecting data. Therefore a predefined mis-adjustment in **Y** wirebond should be known to get deviation on **X (frequencies, current and deformation)** data.

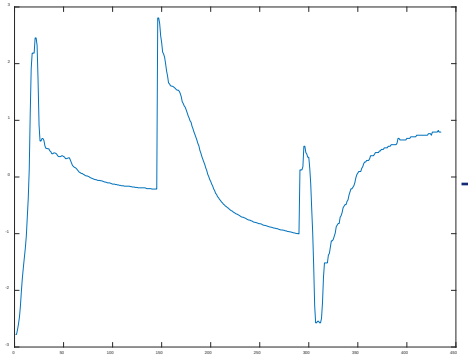


Design and Implementation – Methods & AI Algorithms

- Pre-processing using z-Score
- Dimensionality reduction using PCA
- Anomaly detection using gaussian mixture model
- Evaluation using non-negative log likelihood

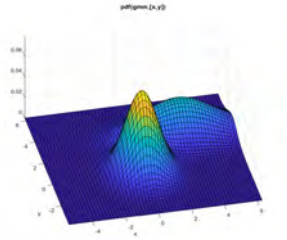
IFAG APC system





Pre-processing

Z-Score + PCA



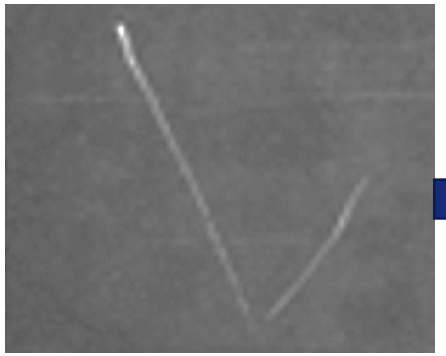
Gaussian mixture model

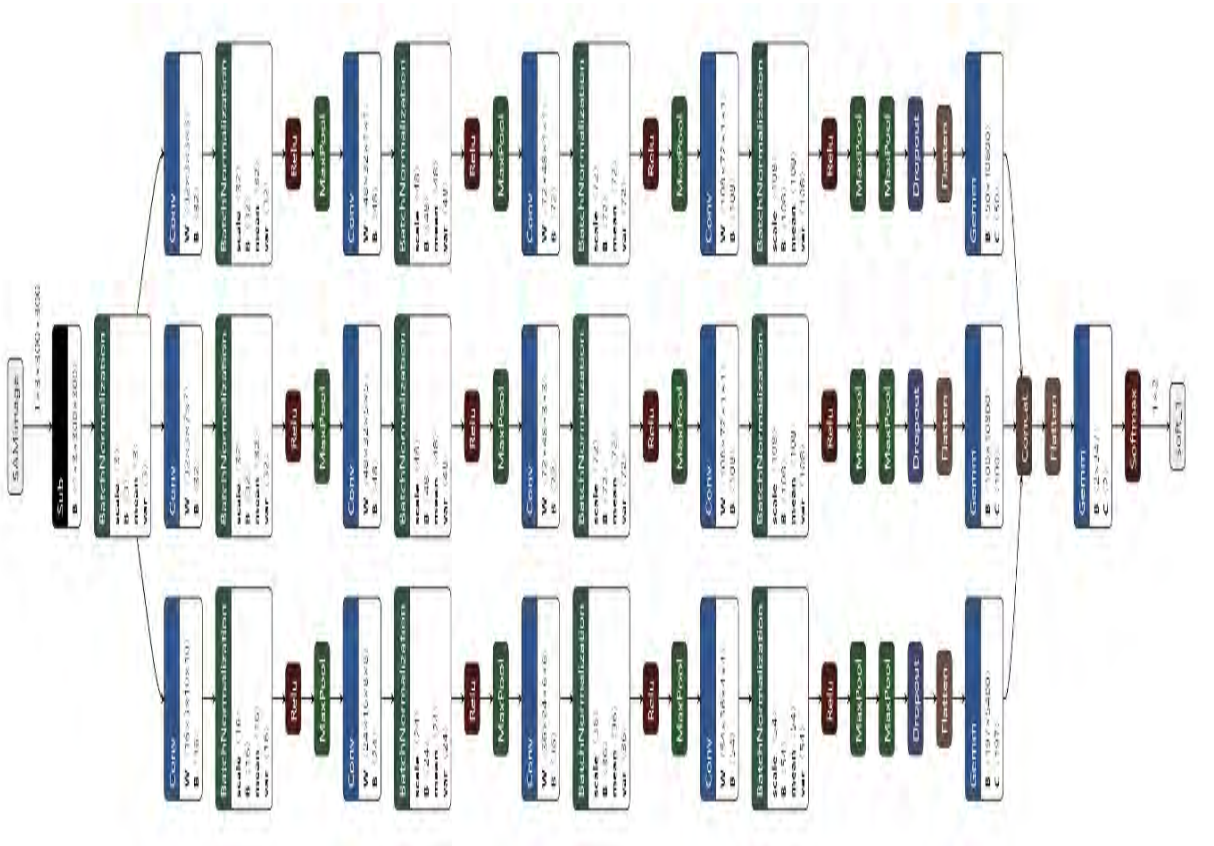
Anomaly-detection

Non negative
log-likelihood

Design and Implementation – Methods & AI Algorithms

Input image





SCRATCH :98%

PARTICLE: 2%

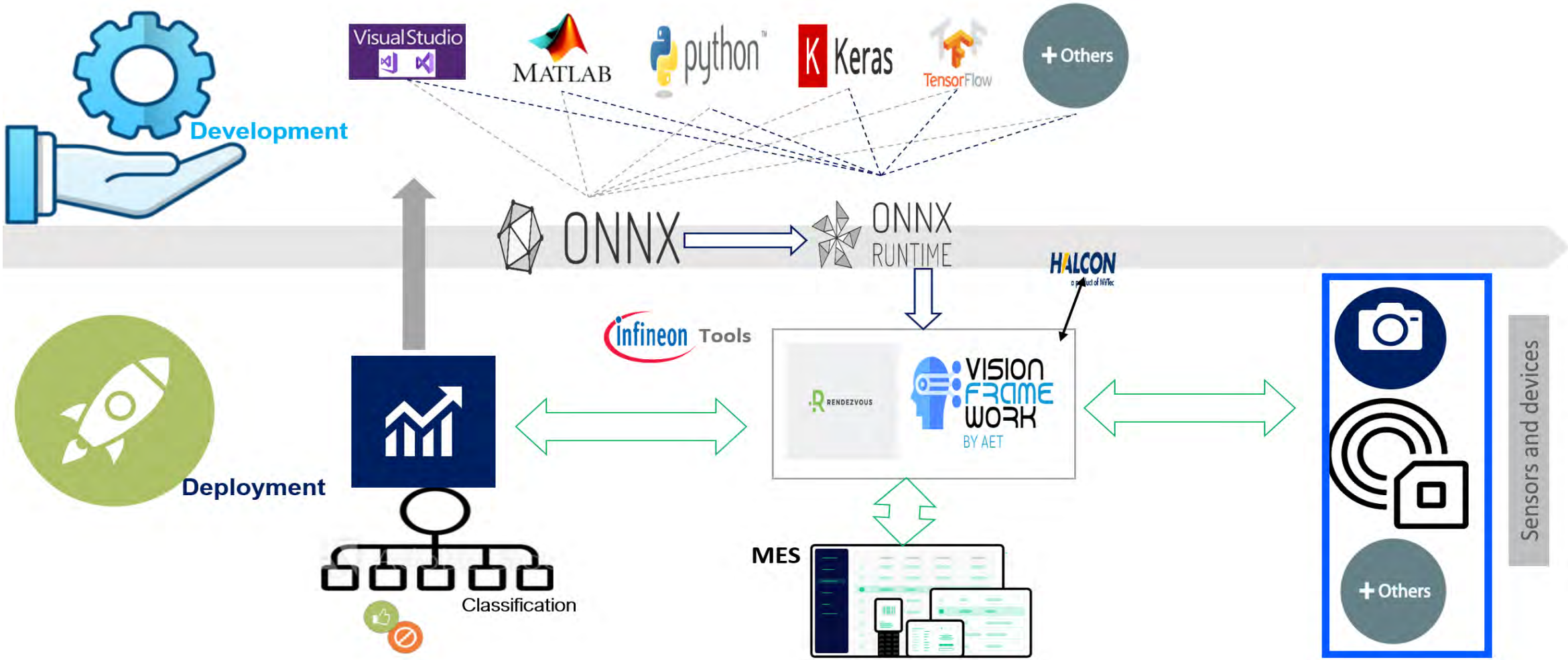
PASS: 0%

CNN with ~100 layers

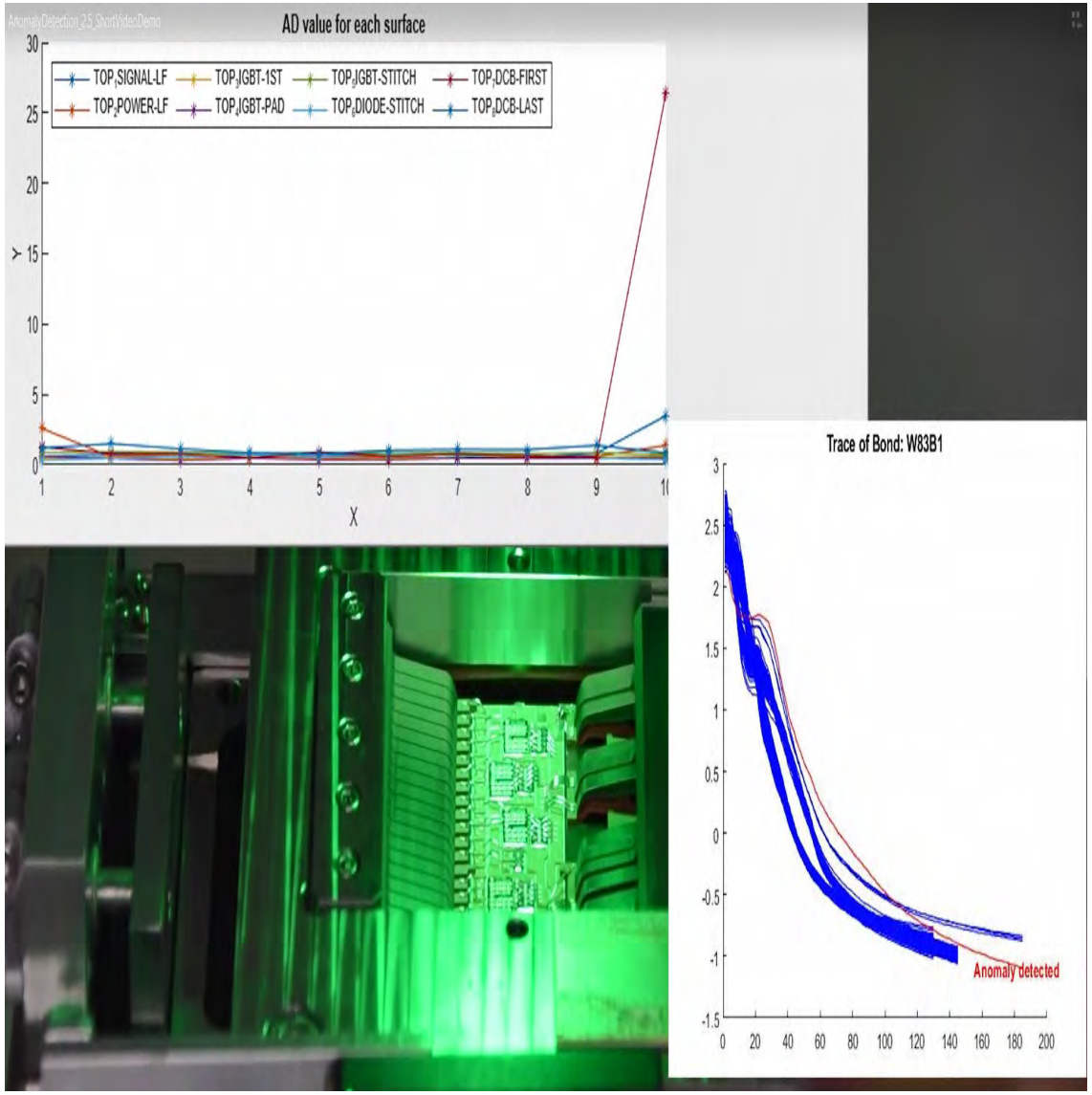
Each bclock in the CNN consist of:

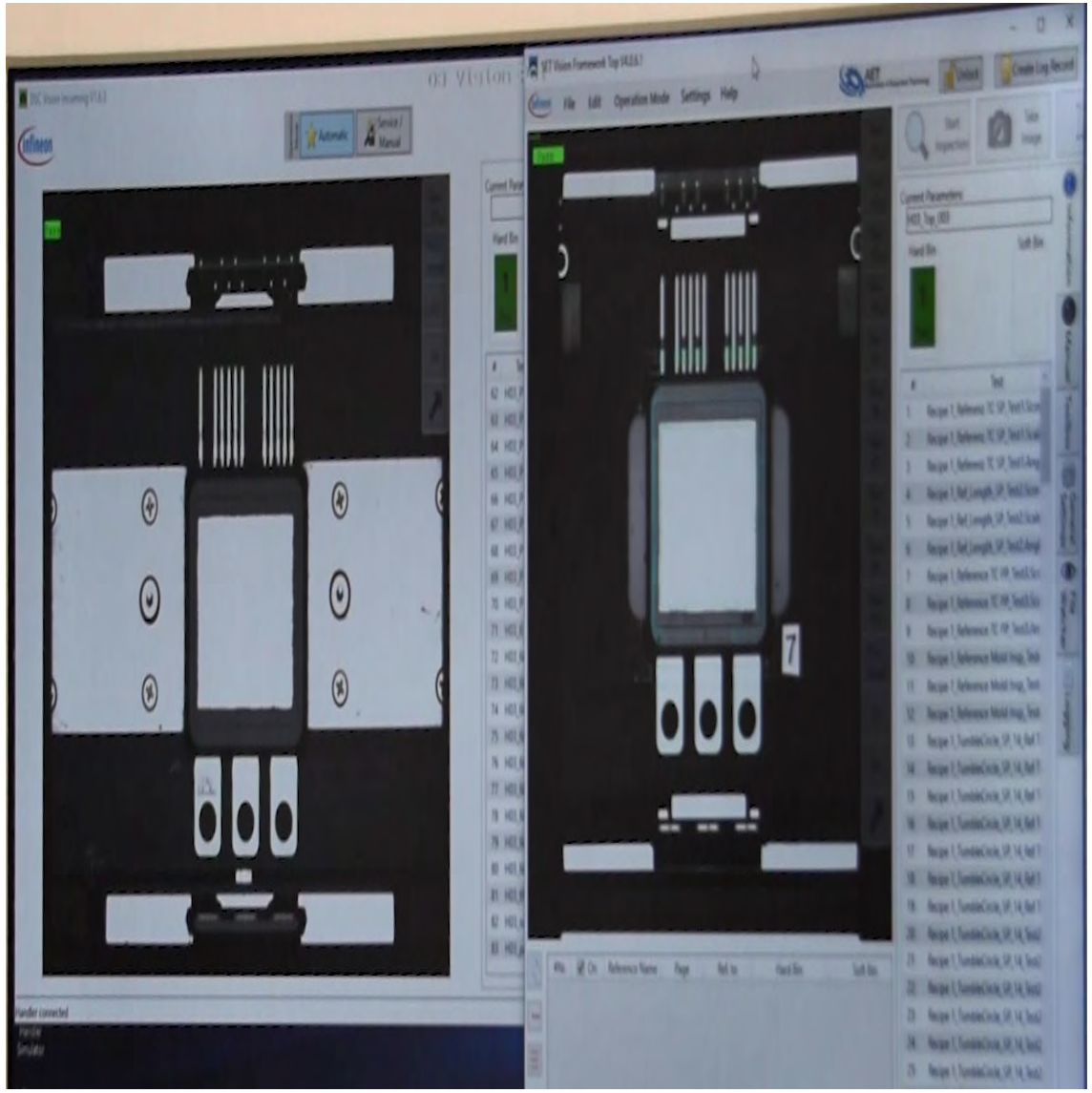
- Convloutional layer
- Batch normalization layer
- Pooling layer
- Rectified Linear Unit

Design and Implementation – AI Framworks



Design and Implementation – AI Framworks

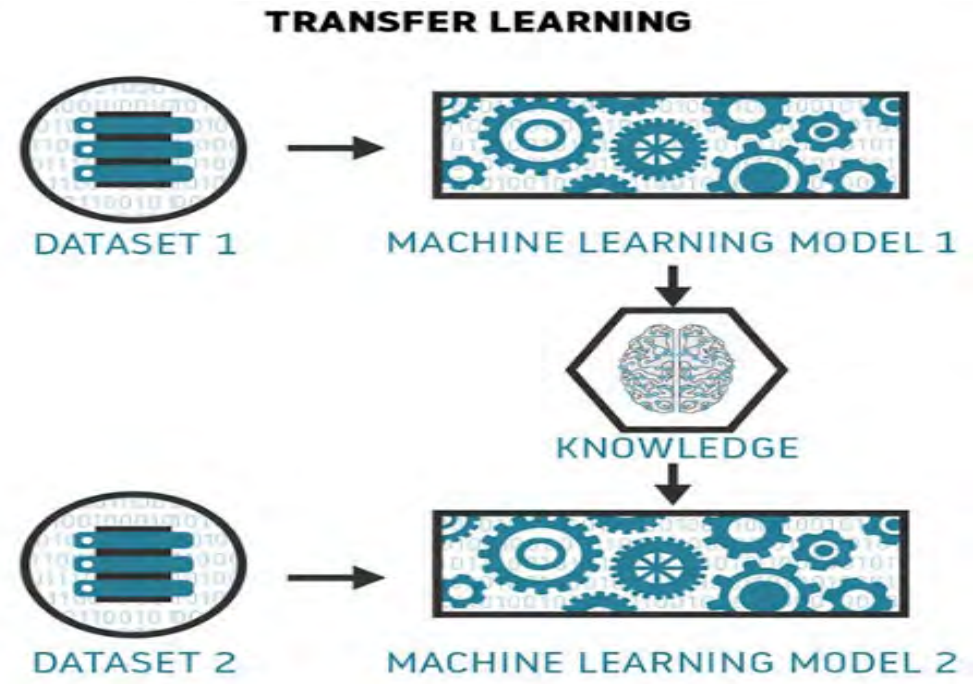


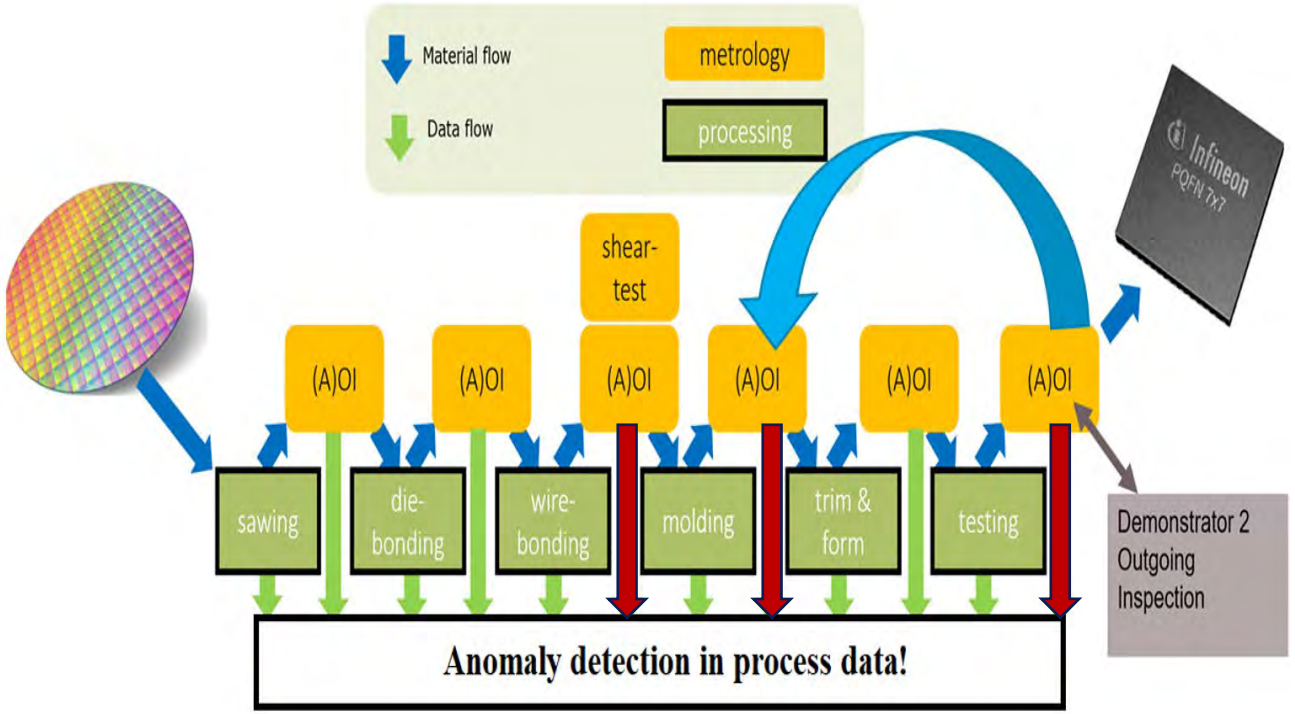


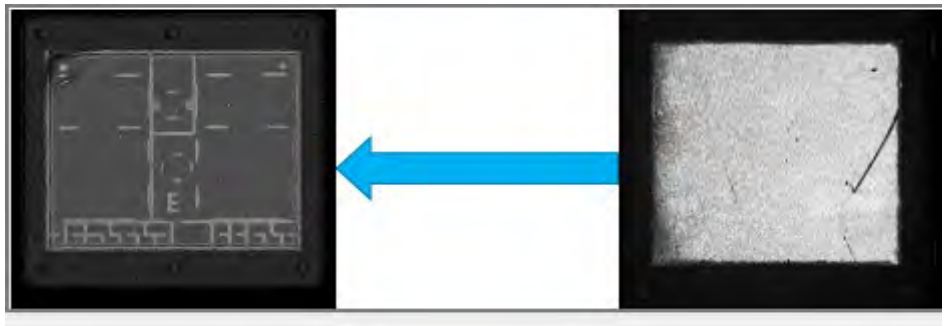
Design and Implementation – Transfer learning and scalability

Idea:
Instead of training deep learning model from scratch for the new task:

- Take the pretrained net on the previous task for the new task
- Adapt it for your domain and the target new task.

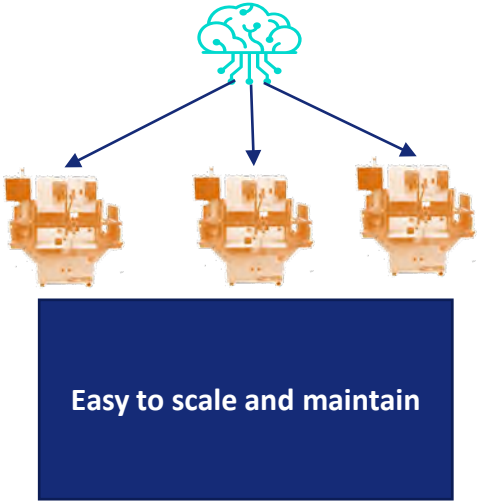




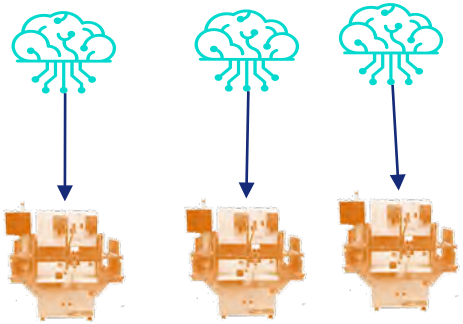


Design and Implementation – Transfer learning and scalability

- However, two technical approaches are considered possible
  - A: with aligned machines
    - One model for a specific surface covering all products
    - Model includes data for each machine
  - B: with unaligned machines
    - Specific model for each product and machine



Easy to scale and maintain



More sensitive and accurate

Experimental Results & Conclusions

- Currently the anomaly detection for wirebonding is running on over 40 machines on 3 different IFX sites.
- During a runtime of 4 months, several misadjusted bonders were detected, random errors and contaminated devices.
- For *OOI*, a model has been evaluated on unseen productive data and the accuracies was as the following
  - *OOI*

BOT

	Defect	Good
Defect	250	379
Good	0	39921
Acc.: 99,07%	*Sen.:*100%	*Spe.:*99,06%

TOP

	Defect	Good
Defect	130	220
Good	0	25000
Acc.: 99,13%	*Sen.:*100%	*Spe.:*99,13%

Experimental Results & Conclusions

- New process(after transfer learning):

BOT

	Defect	Good
Defect	227	198
Good	0	26063

Acc.: 99,25% *Sen.*:100% *Spe.*:99,25%

TOP

	Defect	Good
Defect	751	60
Good	1	9353

Acc.: 99,40% *Sen.*:99,87% *Spe.*:99,36%

- ✓ The two use cases show the potential benefits of using AI models in detecting abnormalities in industrial packages.
- ✓ Moreover, the methodology shows the possibility of scaling such solutions to new similar use cases or machines with minimum effort.

Event Organisers

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Thank You

For your attention

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